Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/648
GREECE
February 1964
Submitted in:
ENGLISH and FRENCH

Confidential until official release during Conference

Abstract

DETERMINATION OF l_{eff} AND β_{eff} IN A CRITICAL REACTOR BY THE PULSED NEUTRON TECHNIQUE

C. Stassis and C. Mitsonias
Nuclear Research Center Democritus, Reactor Department, Greece

The values of l_{eff} and β_{eff} for a critical reactor were determined by the pulsed neutron technique. The method is based on the analysis of the rise and the decay of the thermal neutron density produced by injection of a fast neutron pulse in the reactor.

The response of an essentially homogeneous reactor to a square fast neutron pulse of intensity S_1 and duration Δ is given by:

$$n_1(0 \leqslant t \leq \Delta) = n_o + SBt + S \sum_{j=1}^{6} A_j (e^{a_j t} - 1) \quad \text{and} \tag{1}$$

$$n_1(t \geqslant \Delta) = n_o + SB\Delta + S \sum_{j=1}^{6} A_j e^{a_j t} (1 - e^{-a_j \Delta}), \tag{2}$$

where

$n_1(t)$ is the thermal neutron density for the first pulse,

n_o is the thermal neutron density at $t=0$,

$$B = 1/\left(1 + \frac{1}{l_{eff}} \sum_{i=1}^{6} \frac{\beta_i}{\lambda_i}\right) \tag{3}$$

$$A_j = \prod_{i=1}^{6} (a_j + \lambda_i) / a_j^2 \prod_{i \neq j} (a_j - a_i) \qquad j = 1, 2, \ldots 6, \tag{4}$$

a_j are the roots of the equation

$$1 + \frac{1}{l_{eff}} \sum_{i=1}^{6} \frac{\beta_i}{s + \lambda_i} = 0, \tag{5}$$

S is proportional to S_1,

and a_6 is the most negative root of equation (5) and characterizes the prompt neutron decay.

Equation (1) reduces to

$$n_1(0 \leqslant t \leqslant \Delta) = n_o + S(B+1)t \qquad (6)$$

for $|a_j t| \ll 1$, taking into account that $A_6 \cdot a_6 \simeq 1$

The thermal neutron density during the time of the m^{th} neutron pulse in m consecutive pulses of period $T \gg 1/|a_6|$ will be

$$n_m\left[(m-1)T \leqslant t \leqslant (m-1)T+\Delta\right] = n_o + (m-1)SB\Delta + S(B+1)t \qquad (7)$$

where $(m-1)SB\Delta$ takes into account the rise of the power level due to the previous (m-1) pulses.

In the conduct of the experiment the accumulation of m consecutive pulses gives a number proportional to:

$$n(t)=n_1+n_2+\ldots+n_m=mn_o+\frac{m(m-1)}{2}SB\Delta+mS(B+1)t \qquad (8)$$

In analyzing the experimental results it is noted that

a) the slope X of the straight line obtained from the experimental plot of equation (8) is proportional to $mS(B+1)$ and

b) the measurement of "initial" (mn_o) and "final" ($mn_o+\frac{m(m+1)}{2}SB\Delta$) background gives a quantity Y proportional to $\frac{m(m+1)}{2}SB\Delta$.

Combining the measured quantities X and Y one obtains l_{eff} as a function of $\beta_{i,eff}$ using the known values of λ_i. The decay constant a_6 can be determined directly as the most negative root of equation (5). The values of $\beta_{i,eff}$ may be adjusted so that a_6 calculated above coincides with the measured one from the decay of the pulse.

The measuring equipment consists of a 14 MeV pulse neutron generator, a 512 channel multiscaler and an automatic device to preset the number of pulses.

This method has been used to determine the values of l_{eff} and β_{eff} for the "Democritos" reactor.